

APPENDIX F

Wetlands and Environmentally Sensitive Areas

Lower West Coast Water Supply Plan -- Appendix F

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FACTORS AFFECTING WETLANDS AND ENVIRONMENTALLY SENSITIVE AREAS

Factors which influence wetland systems and environmentally sensitive lands include hydrology, fire, geology and soils, climate, and ecological succession. This section presents an overview of each of these factors.

Hydrology

Hydrology is the single most important determinant for the establishment and maintenance of specific types of wetlands and wetland processes (Mitsch and Gosselink, 1986). Hydraulic inflows and outflows, such as precipitation, surface runoff, ground water inputs, and in some cases, tides and river flooding, provide the energy to transport nutrients and other organic material to and from wetlands. Water depth, hydroperiod, flow patterns, stage, duration, frequency of flooding and water quality all influence the biochemistry of wetlands and ultimately, the species composition and type of wetland community that develops. The hydrology of a wetland acts both as a limit and a stimulus for determining the numbers, types (species), and growth rates of flora and fauna that can live within a specific wetland. For example, the growth rates of pine trees appear to be affected by water table depths. Slash pine growth rates in flatwoods generally increase in proportion to the depth to the water table, indicating the inhibitory effect of excessive moisture (Duncan and Terry, 1983). At the other extreme, tree growth can be limited by a lack of available moisture during the dry season (Haines and Gooding, 1983). Hydrology also strongly affects aquatic primary production, organic accumulation, and the cycling of nutrients (Mitsch and Gosselink, 1986).

Precipitation

The LWC Planning Area experiences wide variations in annual rainfall, resulting in flooding and extended drought periods. During heavy rainfall years, there is overland flow and discharge to the ocean. During extended drought years, however, the natural system is stressed by saltwater intrusion, increased frequency of fires, loss of organic soils, and invasion of wetlands by exotics. The region averages about 53 inches of rainfall annually, with approximately two-thirds falling during the summer months (Duever *et al.*, 1986). During the dry season (November-April), precipitation is governed largely by large-scale winter weather fronts which pass through the region roughly every seven days (Bradley, 1972). Rainfall from these fronts exhibit a uniform distribution pattern as compared to precipitation derived from the highly variable, convective-type thundershowers which are characteristic of the wet season (May-October).

Evapotranspiration

Evapotranspiration (ET) is the combined process of evaporation from land and water surfaces, and transpiration from plants. ET rates vary as a function of solar radiation, air and water temperature, relative humidity, wind velocity and duration and the type and density of vegetation (Duever *et al.*, 1986). In South Florida, ET ranges from 70 to 95 percent of annual rainfall. During the dry season and drought years, ET exceeds rainfall inputs (Klein *et al.*, 1975). Temperature is often regarded as the most important factor controlling ET. Minimum ET rates occur during the winter months of December and January, with highest values experienced during the spring months of April and May. Typical ET values for South Florida range from 40 to 45 inches a year, up to a maximum of 60 inches a year (Parker *et al.*, 1955). ET

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rates frequently account for virtually all water losses in a wetland because of their slow rate of flow and high surface area to depth ratio (Mitsch *et al.*, 1988). As a result, ET plays a very important role in the development of any hydrologic model that might be developed for a particular wetland system and is usually the most difficult parameter to estimate. Wetlands have higher ET rates than other habitats largely because they store water near the ground surface where it can be lost to the atmosphere (Duever, 1988).

Hydroperiod

Hydroperiod refers to the annual period of water level inundation, specifically the length of time (duration) that a wetland contains water above ground level. Figure F-1 presents examples of typical hydroperiods experienced by three different South Florida plant communities. Duever *et al.* (1986) reports that hydroperiod is the dominant factor controlling both the existence, plant community composition and succession of South Florida wetland systems. Hydroperiod is often expressed in terms of the range of the number of days that a wetland is normally inundated. For example, in the Big Cypress Preserve, Duever *et al.* (1986) reports that freshwater marshes are usually found on sites having a hydroperiod of 225 to 275 days per year, as compared to a pond system which is inundated year round. Each wetland type is thought to have a hydrologic signature that describes the rise and fall of water levels from year to year (Mitsch and Gooselink, 1986). Duever *et al.* (1986) found that work conducted at Corkscrew Marsh "has clearly shown that the distribution of undisturbed upland, marsh, swamp and shallow aquatic habitats are largely a function of a site's hydroperiod." In contrast, O'Brian and Ward (1980) state that from a hydrological point of view, the most significant feature of a wetland is the level of the ground water table. They point out that the depth to the ground water table is more significant than the hydroperiod or time the wetland is flooded.

Water Level Depth and Timing

In South Florida's freshwater wetlands, wading bird nesting success is highly dependent on present and past water level conditions, which influence the amount and availability of wading bird prey items, such as crayfish and small forage fish (Kushlan, 1976, 1978, 1979, 1980, 1986; Powell, 1987; and Frederick and Collopy, 1988). Ecological studies of Southwest Florida wetlands have found a direct relationship between numbers of wading bird breeding attempts and the amount of rainfall preceding the breeding season (Ogden *et al.*, 1980, 1987). Kahl (1964) found that the timing and initiation of wood stork breeding attempts was predictable from the measurement of marsh surface water levels. Kushlan *et al.* (1975) found that wading bird nesting success was directly related to the rapid winter/spring recession of water levels (drying rate) of South Florida wetlands. Therefore, maintenance of appropriate water depths and timing of wetland water level fluctuations is a critical factor in determining wading bird nesting success.

Topography

In general, wetlands in temperate and tropical regions tend to develop in areas of low topographic relief and high rainfall inputs. Topography also controls the shape and size of watersheds, and affects the timing and quantity of runoff. Topography is also an important factor in controlling the vertical and horizontal extent of seasonal water level fluctuations within a wetland. In the Big Cypress swamp, Duever *et al.* (1986) found that wetlands dominate much of South Florida because: (1) the flat topography reduces runoff to a minimum, (2) high rainfall during the warm part of

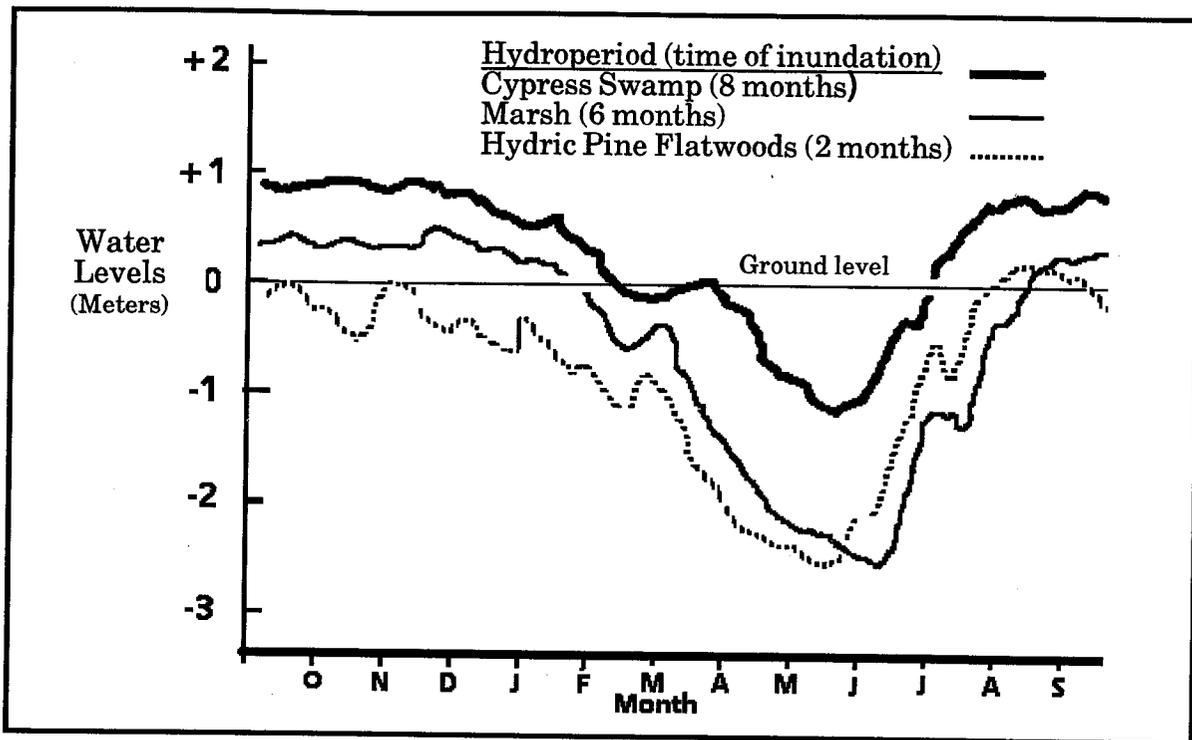


FIGURE F-1. Hydrographs and Hydroperiod Ranges for for Three Different South Florida Vegetation Types. (From Duever *et al.*, 1986).

the year compensates for high ET losses, and (3) low ET rates during the the cool part of the year approximates rainfall inputs. At the site-specific level, wetlands are determined by the depth and duration of inundation, which in turn are influenced by site microtopography (differences in water depth of only a few centimeters), soil type, and vegetation cover (Duever *et al.*, 1986).

Vegetation Type

Vegetation type can affect the hydrologic cycle of a wetland, primarily through ET. Vegetation also influences water movement and water quality. Plant leaves, leaf litter and attached periphyton (algae) communities tend to impede water flow which: (1) increases the period of inundation, (2) reduces surface water runoff and erosion, (3) allows more time for aquifer recharge, and (4) assimilates nutrients and chemical exchanges between the soil vegetation and water (Duever *et al.*, 1986).

Tropical Storms and Hurricanes

Hurricanes, tropical cyclones which generate winds in excess of 75 miles per hour, are recurrent events in South Florida and are important physical processes which affect the regional ecology (Craighead and Gilbert, 1962). Southwest Florida has been identified by the National Weather Service as one of the most hurricane-vulnerable areas of the United States. Hurricanes normally cause the greatest amount of damage when wind velocities average greater than 111 miles per hour. Such storms have passed within 100 miles of Fort Myers on the average of once every five-and-one-half years from 1900 to 1985 (SWFRPC, 1990).

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Coastal flooding from tropical storms or tropical depressions occur commonly within the LWC Planning Area, causing flooding in low-lying areas, along barrier islands, and near river and bay systems (SWFRPC, 1990). Although these storms are destructive to life and property, they appear to be an important component of the region's natural hydrological cycle, often occurring following several drought years to replenish surface and ground water sources. These storms also appear to be an important source of fresh water and nutrient inputs into Florida Bay (Meeder and Meeder, 1989).

Fire

Fire is also an important factor controlling the species composition, distribution and succession of wetland communities in the LWC Planning Area. Within the constraints of wetland hydrology, fires occur with variable frequency and severity affecting plant succession.

Theoretically, hardwood hammocks represent the climax plant community for South Florida (Alexander and Crook, 1973; Wharton *et al.*, 1977; Duever, 1984). Hammocks develop when fire is absent or infrequent, and organic soils are allowed to build up over time to support the succession of hardwoods (Figure F-2). However, fire is a common component of the South Florida landscape. In the Everglades, fires occur, on the average, every seven years. Few areas escape fire; thus hammocks are relatively uncommon and occur only on elevated sites where fire is infrequent. Most sites which are high enough to support hammocks are occupied by pine flatwoods which are tolerant of periodic fire (Duever, 1984).

Wetlands are subject to fires during the dry season. Marshes which dry out and burn with enough frequency do not allow the establishment of cypress forests. Cypress dominated wetlands occur on wetter organic soils which burn less frequently. Before man settled the region, the majority of fires were caused by lightning strikes during the wet season. As more people moved to the region, more fires occurred during the winter dry season. These fires are typically more severe and extensive since they occur during the dry season when wetland soils are dry.

Geology and Soils

The primary geological feature that controls regional hydrology is the permeability of the underlying rock. Limestone with deposits of quartz sand, clay and shell comprise the underlying aquifer. A more detailed description of the region's geology and underlying aquifer system is found in Chapter III.

Two primary factors which affect the hydrogeology of wetlands are the porosity and permeability of its underlying soils (Duever, 1988). A highly porous soil can hold or store large amounts of water, while a highly permeable soil allows water to flow to the underlying aquifer. The high capillary action of peat or clay soils enable wetlands to store large quantities of water, somewhat similar to how a sponge takes up water.

Some wetlands contain perched water tables. A perched water table exists where a saturated soil layer is found above a water table and is separated from it by an unsaturated zone (Freeze and Cherry, 1979). This can occur where a relatively impermeable clay or organic soil layer is present near the ground level and restricts the downward movement of water. Perched water tables come in various sizes and can influence surface water levels over large areas or have only local, temporary

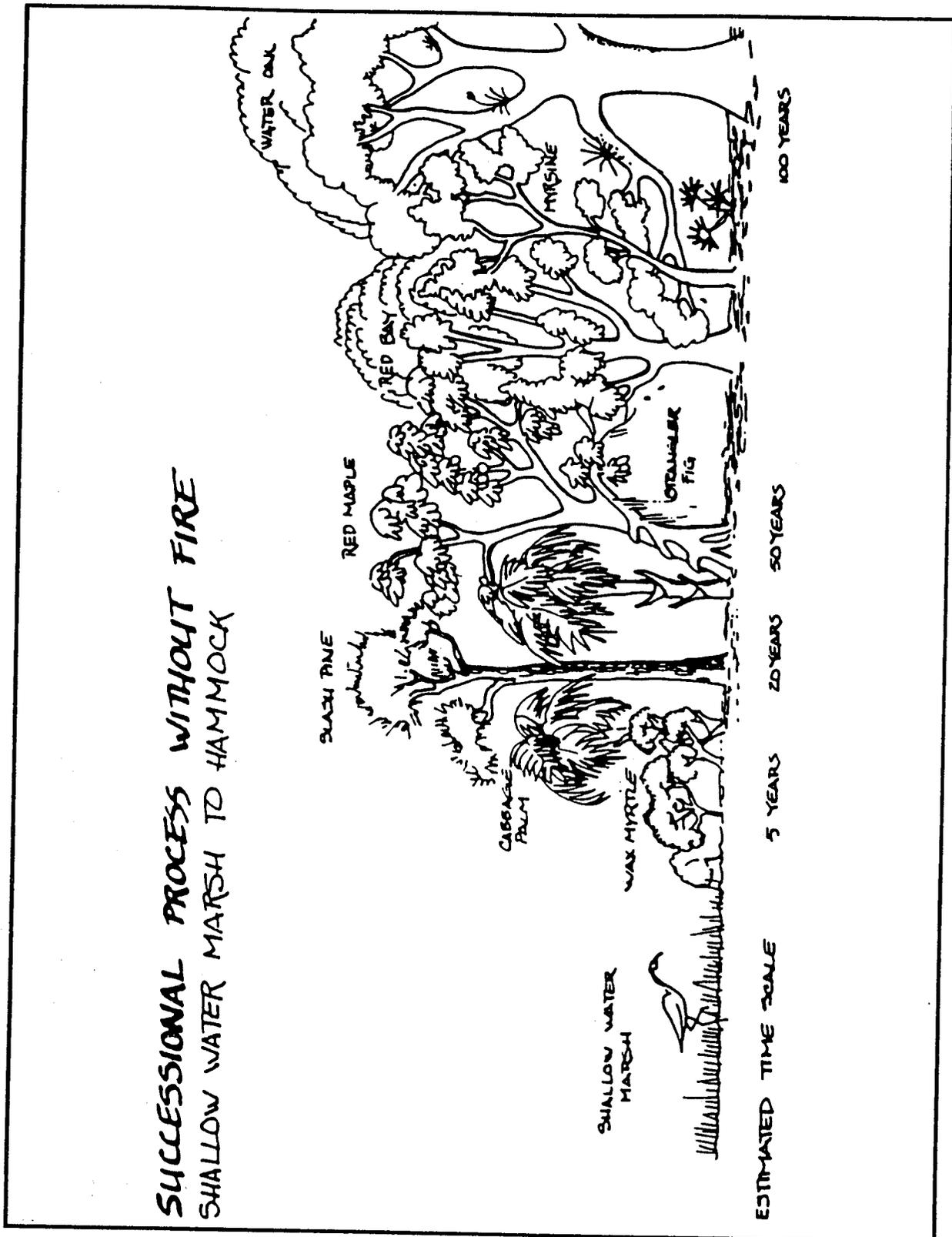


FIGURE F-2. South Florida Successional Pattern without Fire: Shallow Water Marsh to Hammock (From Wharton *et al.*, 1977).

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effects (Duever, 1988). A common misconception is that wetlands can only occur on sites containing a perched water table. Although this may be the case in some areas, Duever's (1988) experience in Southwest Florida indicates that wetland water levels coincide with the regional water table. Situations which at first appeared to be a perched water table turned out to represent unusual or transient conditions.

Climate

In addition to hydrology and fire, climate also plays an important role in controlling plant community succession. The areal extent, species composition, and existence of wetlands are all affected by long-term climatic changes. In addition to normal cyclic drought and flood conditions, long-term cycles have the ability to produce gradual, and nevertheless, major shifts in the normal year-to-year range of hydrologic conditions. As climatic cycles become wetter, wetlands will tend to cover larger areas of the landscape. Wetland communities would also tend to become more diverse as a result of the presence of greater ranges of hydroperiods on different topographic sites. A wetter climate might also increase the rate of peat accretion in wetlands, thus encouraging the development of edaphic plant communities. Long-term drier conditions might produce the opposite effects. A wetter or dryer climate might also affect the frequency of fire, shifting plant community succession. A major difficulty in managing wetlands is our inability to distinguish between shifts in hydrologic conditions that result from man's activities and those that result from occasional natural events or long-term shifts in climate (Duever, 1984).

Succession

Overdrainage of wetlands and reduction of hydroperiod length directly influences the direction of plant community succession within a wetland. McPhearson (1973) reported that "differences of only a few inches in depth or changes in period of inundation will determine, in time, what plant communities are present [in the Everglades]." Numerous investigators have documented changes in the species composition of South Florida plant communities resulting from altered water level conditions (Davis, 1943; Loveless, 1959; Kolipinski and Higer, 1969; Dineen, 1972, 1974; Alexander and Crook, 1973, 1988; Schortemeyer, 1980; Worth, 1983). Duever *et al.* (1976) used fire frequency and hydroperiod data to establish a basis for the occurrence of plant community succession in Corkscrew Swamp. This relationship is presented in Figure F-3. The successional relationships of South Florida wetland and upland plant communities have also been discussed by Alexander and Crook (1973), Craighead (1971), Davis, (1943), Wharton *et al.* (1977), and Duever, *et al.* (1986). These data are useful for making a general assessment of the direction that succession may take as a result of increasing or decreasing hydroperiod in a Southwest Florida wetland.

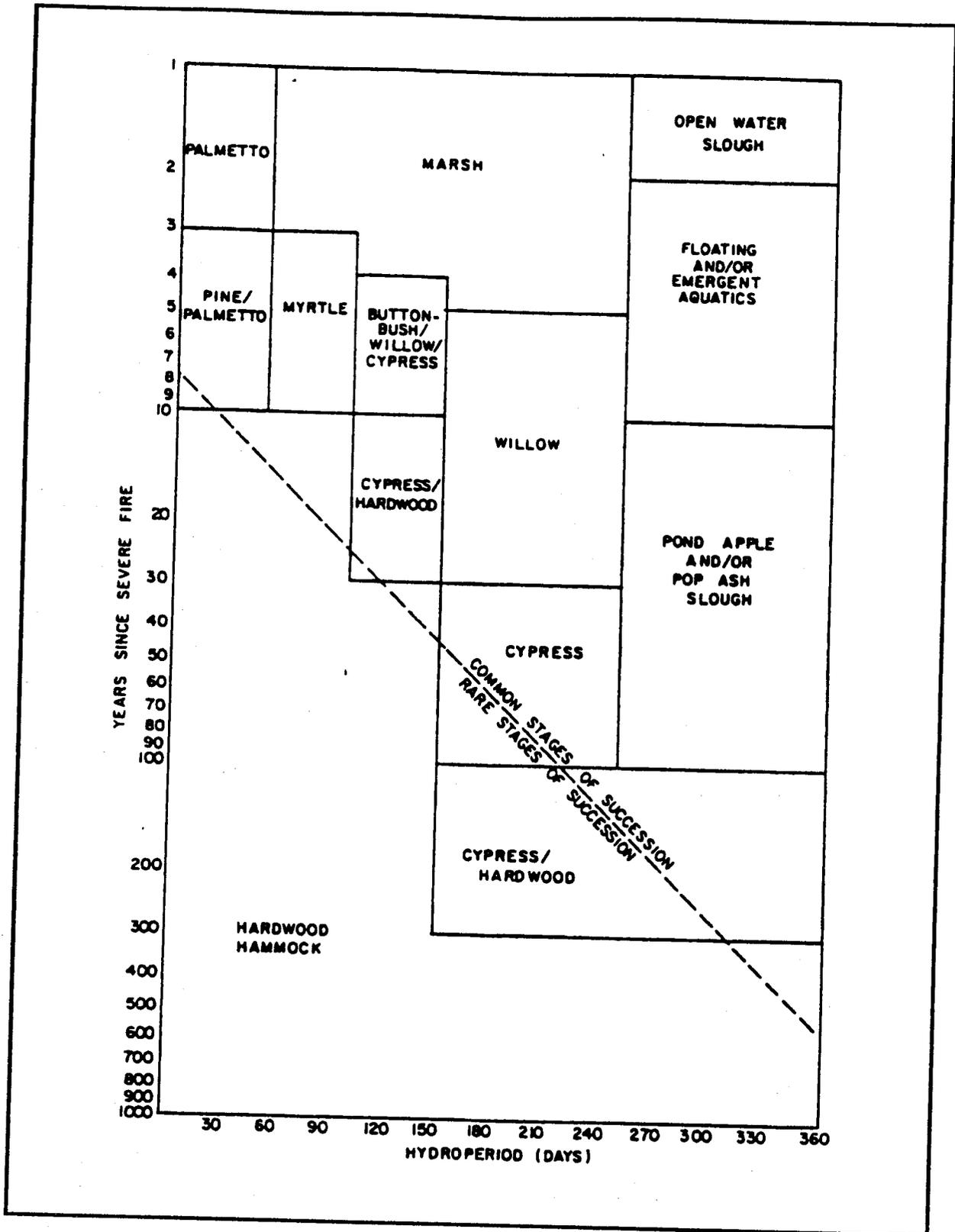


FIGURE F-3. Successional Patterns and Rates within South Florida Inland Plant Communities (From Duever *et al.*, 1984).

REGIONAL ENVIRONMENTAL ISSUES

Loss of Wetlands

According to the U.S. Fish and Wildlife Service (1990), Florida has lost over 9.3 million acres of wetlands between 1780 and 1985, a 46 percent loss. During the 1970s and 1980s, despite strict environmental regulations, Florida lost, on average, over 26,000 acres of wetlands annually, which is the equivalent of losing 70 acres of wetlands each day. Almost all of these losses are the result of conversion of wetlands to agriculture, urban and other built-up areas (Frayner and Hefner, 1991). It was estimated that in 1780, Florida had over 20.3 million acres of wetlands; the state now has less than 11 million acres. Florida's losses represent over 15 percent of the national loss annually (U.S. Congress, 1984).

In Southwest Florida, large-scale loss of wetlands occurred during the 1960s and 1970s. Urban and agricultural development has affected both the quantity and quality of remaining wetlands. In Lee County, continued urban growth has altered the county's natural systems over the past 50 years. In the northwest portion of the county, the peninsula now occupied by the City of Cape Coral originally consisted of sloughs, marshlands, and seasonal ponds. Almost all of this original habitat has been lost to development. Lehigh Acres, another large-scale residential development located in the eastern part of the county, has also resulted in the ditching and draining of thousands of acres of the original wetland/upland mosaic. Other parts of the county have been converted to cropland and improved pasture.

In Collier County, a single large development, Golden Gate Estates, attempted to drain 110,000 acres of pristine forested and emergent wetlands. This project dug 183 miles of canals, constructed 813 miles of roads, and sold over 50,000 individual lots to buyers worldwide (Frayner and Hefner, 1991). Construction of two primary canal systems, the Golden Gate Canal and the Faka Union Canals, disrupted natural drainage patterns and lowered ground water levels to control flooding and make land suitable for development (Klein *et al.*, 1970; Carter *et al.*, 1973; McPherson *et al.*, 1976). Along the coast of Collier County, south of Naples, a large resort community was built on Marco Island. Construction of this community converted approximately 5,300 acres of mangroves and uplands to finger canal subdivisions. Collier County has also experienced a large amount of growth along its northern coastal area. This growth has the greatest impact on the estuarine communities affected by the alteration of both the quantity and quality of the freshwater runoff they receive. Construction of Alligator Alley (State Road 84), Tamiami Trail (U.S. 41), I-75 and State Road 29 have all impacted historical surface water flow patterns throughout the LWC Planning Area. Heavy use of these roads is a threat to several species of endangered wildlife, including the Florida panther.

The Corkscrew Regional Ecosystem Watershed (CREW) lands represent more than 50,000 acres of environmentally sensitive wetlands and uplands located in Collier and Lee counties. The CREW lands contain five major wetland systems: (1) Flint Pen Strand, (2) Corkscrew Marsh, (3) Corkscrew Swamp Sanctuary, (4) Bird Rookery Swamp and (5) Camp Keis Strand. This area probably represents the largest remaining hydrologically intact wetland ecosystem in South Florida and provides important wildlife habitat to a number of rare, threatened and endangered species.

Potential impacts to CREW include: (a) the possibility of lowered ground water tables and impacts to wetlands as a result of county and municipal wellfield

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development within the watershed, and (b) lowered water table elevations, degraded water quality, and associated wetland impacts caused by the expansion of the citrus and vegetable industries. If properly managed, these lands have the potential to provide a number of benefits to the region. Preliminary data suggests that CREW may offer some degree of water supply for Lee and Collier counties, along with the potential for providing drainage, flood storage and water quality improvements for surface waters discharged to downstream estuaries. The District is currently conducting a hydrologic evaluation of the CREW watershed.

Developments of Regional Impact

Several large developments of regional impact are currently being considered for approval. These proposed developments have the potential to alter surface water flow patterns, deplete ground water supplies, cause alteration of wetland hydroperiods, encourage exotic plant invasion, and impact existing wildlife habitat.

Southwest Regional Airport Expansion

Lee County is currently planning to expand the existing regional airport located in the central portion of the county. Expansion plans call for runway improvements, construction of roads and parking lots, rental car and commuter aircraft parking, a new concourse and associated support facilities. This proposal would impact a minimum of 400 acres of wetlands (Memorandum dated November 12, 1991 from Chip Merriam, Government Assistance, SFWMD, Ft. Myers area office).

Alico DRI

The Alico DRI is an 11,000 acre conceptual plan to develop a 20,500 dwelling units, integrating a mix of industrial, commercial, office, residential, public open space, and recreational land uses. The project has the potential to impact 1,310 acres of wetlands, consisting primarily of cypress wetlands, freshwater marshes, and wet prairies. Environmental concerns focus upon: (a) potential drainage of wetlands and loss of wildlife habitat as a result of wellfield drawdowns, (b) impacts associated with drainage and development, (c) potential water quality impacts to the Estero River and Six Mile Cypress Basin, and (d) the encouragement of more urban sprawl within the central portion of the county, which has the potential to further fragment remaining wildlife habitat.

Gulfview-New Town

The proposed project is a 7,000 acre mixed residential and commercial development. Approximately 1,300 acres of property will be within the Flint Pen Strand as identified by the Save Our Rivers CREW Project. Lee County has proposed the establishment of several wildlife corridors within the county to reduce the detrimental effects of habitat fragmentation; one of these corridors is proposed for this project.

Relocation of Citrus to Southwest Florida

The conversion of upland and wetland habitat to citrus in Hendry County, western Glades, eastern Lee and Charlotte, and northern Collier counties is threatening the area's water resources and remaining wildlife habitat. In the early 1980s, a series of devastating freezes caused serious damage to Central Florida's citrus industry. As a result, many citrus growers have recently migrated to

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Southwest Florida, seeking to reduce the risk of freeze damages to their crop. This has resulted in a major shift in the geographical distribution of citrus within Florida.

Based on the number of trees in the ground, Hendry County now ranks as Florida's number one citrus county, and ranks third in total citrus acreage. Since 1980, citrus acreage in the region has nearly doubled to its current level of 126,000 acres (Table F-1). Much of this growth has occurred in the past three years (Behr, 1989). According to Florida Gulf Citrus News (1990), citrus growers within the Southwest Florida area planted over 7,000 citrus trees on 40 acres each day during 1988 and 1989. This trend is expected to continue through the next decade, with a projection of up to 80,000 hectares (197,680 acres) in citrus production by the year 2000 (Land, 1988). The on-tree value of this production is estimated to be \$380 million dollars annually, given current citrus prices (Behr, 1989).

TABLE F-1. Citrus Acreage and Trees, 1990.

COUNTY	ACRES	TREES
Hendry	73,754	10,387,900
Collier	23,565	3,204,100
Charlotte	11,718	1,241,000
Lee	9,692	1,169,300
Glades	7,523	890,000
Gulf Total	126,252	16,892,300

Source: Florida Gulf Citrus News, 1990.

Impacts on Wetlands

Citrus development requires extensive drainage of the land and lowering of the water table during the wet season to support the growth of crops. Much of the east-central portion of the LWC Planning Area is currently cattle rangeland (improved and unimproved pasture and native rangeland). The drainage requirements for rangeland, however, are significantly different from those required to operate a citrus grove. Pasture and rangeland are typically drained by shallow ditches placed at wide intervals because native grasses can survive long periods of flooding. In contrast, citrus groves are very sensitive to saturated water table conditions and require rapid drainage. As a result, the typical citrus operation requires a rather elaborate and responsive drainage/irrigation system, which includes high capacity wells, pumps, reservoirs, ditches, levees and dikes. Impacts caused by the drawdown of the water table beneath adjacent wetlands is a concern as the industry expands its operation within the region (University of Florida, IFAS, 1991).

Impacts on Uplands

There is a concern that the magnitude and scale of citrus development has the potential to replace most of the remaining upland communities such as flatwoods and xeric scrub habitats which are native to the region. Conversion of large areas of uplands to citrus within Hendry, Lee and Collier counties may significantly affect the regional ecosystem and its remaining wildlife habitat, which borders two federally protected areas (i.e., the Big Cypress National Preserve, Everglades National Park,

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and the Florida Panther National Wildlife Refuge). Some of this development is occurring in areas occupied by threatened or endangered species such as the Florida panther, black bear, red-cockaded woodpecker, gopher tortoise, gopher frog or Florida scrub jay. As illustrated in Figure F-4, much of the Florida panther's range is threatened by citrus development.

Large-scale citrus development is also a source of concern for the natural hydrology of the area. The pumpage capacity required to efficiently operate a typical citrus grove can produce large distortions in the predevelopment surface water hydrology of surrounding areas, thus affecting adjacent wetlands as well as hydric hammock and hydric pine flatwoods areas. Drainage of uplands and wetlands, and loss of surface water storage areas, may also affect ground water recharge rates and impact future water supplies. In addition, significant amounts of fertilizers and pesticides are used in the operation of a typical citrus grove. These contaminants have the potential to be transported off site in drainage waters to downstream receiving waters. Relatively little is known concerning the water quality impacts of a citrus grove operation on adjacent land uses or water bodies.

Impacts of Ground Water Drawdowns on Wetlands

Expansion of existing county and municipal wellfields in central Collier, southeastern Lee and Hendry counties, and the associated effects of lowering regional ground water tables is a concern for existing wetland systems within the LWC Planning Area.

Relatively little information exists which describes the impact of large-scale agricultural wellfield drawdowns on wetland systems in the LWC Planning Area. Regulatory agencies, such as the SFWMD, face a difficult problem in developing scientific rationale for quantifying the effects of ground water pumpage on wetlands (Watson, 1990), specifically the depth which the water table can be lowered before an impact can be detected within a wetland. The majority of available information presented below has been derived from municipal wellfield drawdown studies.

The effects of municipal wellfield drawdowns on wetlands have been well documented by the Southwest Florida Water Management District (Rochow, 1982, 1983, 1984, 1985; Rochow and Dooris, 1982; Dooris *et al.*, 1990; Watson *et al.*, 1990; Rochow and Rhinesmith, 1991). Over a 15-year period, the SFWMD has produced more than a dozen technical reports from their wellfield monitoring program concerning the effects of ground water withdrawals on wetland ecosystems. In general, these data indicate that long-term wellfield drawdowns greater than one foot result in "unacceptable ecological change" to wetland communities. These changes (from Dooris *et al.*, 1990) include:

- Invasion or establishment of terrestrial plant species creating a "disturbed" appearance and potentially allowing for invasion by exotics
- In severe cases, lowered water table elevations have caused cypress tree mortality and loss of canopy cover
- Increased susceptibility to damage by fire and increased numbers of destructive fires causing changes to community structure
- Loss of organic soils and increased soil subsidence.
- Loss of wildlife habitat and wildlife resources.

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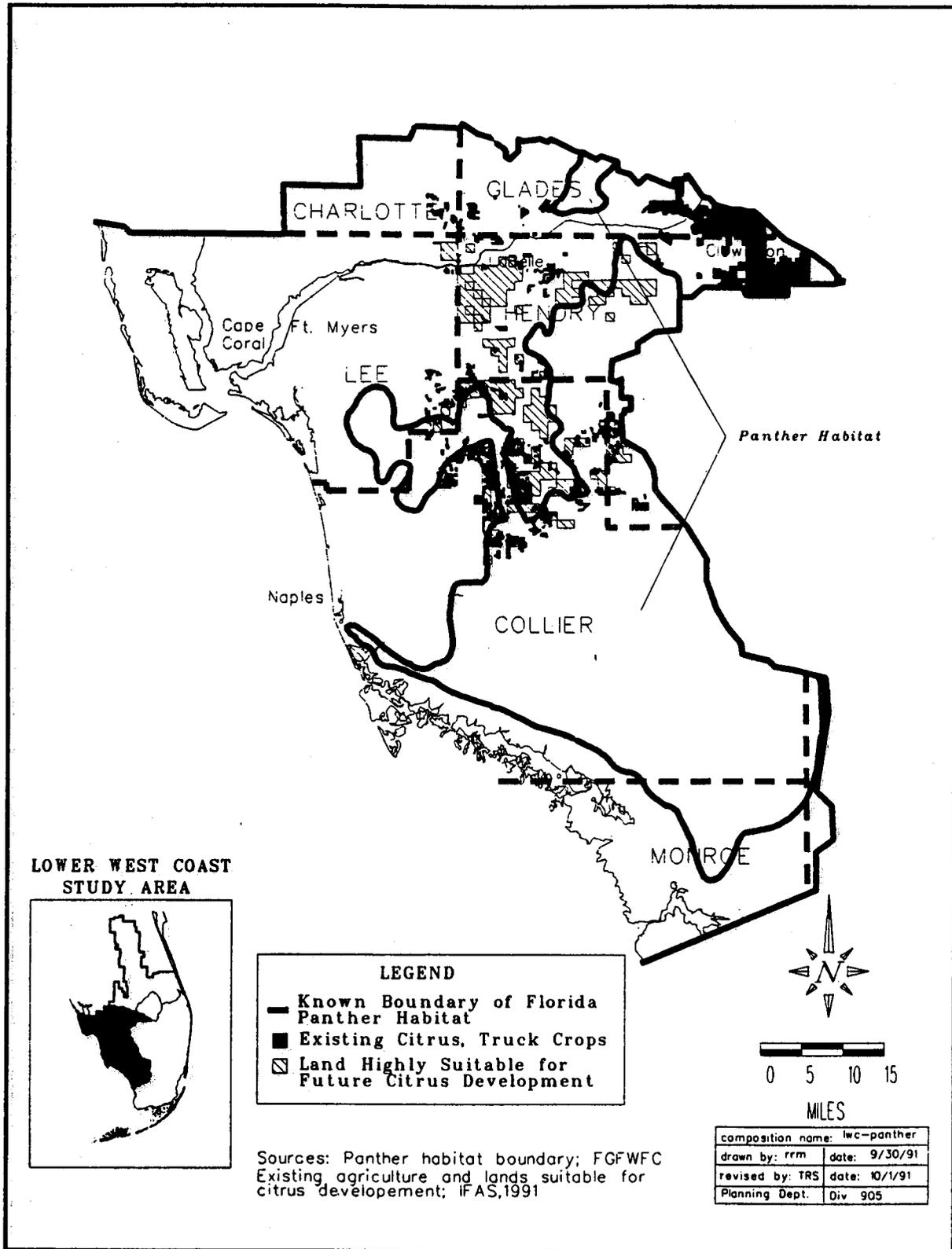


FIGURE F-4. Florida Panther Habitat and Permitted Citrus in Southwest Florida.

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Hydrological and biological monitoring of the Starkey Wellfield has shown that a 0.6 foot water table drawdown corresponded to a noticeable replacement of wetland plant species with those more adapted to upland sites (T.F. Rochow, 1989).

In the LWC Planning Area, relatively little work has been directed towards determining the effects of wellfield drawdowns on wetland ecology. The majority of available information has focused upon the ecological impacts of lowered water tables caused by drainage canals. In a study of the Big Cypress Swamp, Carter *et al.* (1973) described the impacts to cypress wetlands from drainage. Burns (1984) studied the effect of declining water levels within a Fakahatchee Strand cypress community. Results showed that lowering of the water table by an average of 50 cm (1.6 ft.) significantly decreased biomass and net production of the cypress strand. Within this same strand system, Carter *et al.* (1973) and Burns (1984) found a tenfold decrease in primary productivity, extensive thinning of the cypress forest canopy, and a reduction in the rate of forest litter decomposition, leading to buildup of fuel for destructive wildfires. Related observations in the Big Cypress Swamp indicate that extensive dewatering of certain areas of the swamp over the past three decades has led to widespread invasion of cypress communities by slash pine, red maple and red bay. In areas that were previously lumbered and burned, willow is the dominant canopy species for decades to come (Duever *et al.*, 1984). In southeast Florida, recent data published by Hofstetter and Sonenshein (1990) showed vegetative changes that occurred from 1978 through 1986 in an Everglades wetland (Northwest Wellfield, Dade County). Results of the study show that wellfield drawdowns shorten hydroperiod, decrease herbaceous marsh vegetation in favor of woody vegetation and allow for invasion by melaleuca.

Loss of Aquatic Productivity

Wetlands are known as one of nature's most productive ecosystems. For the greater portion of the year, wetlands are flooded and therefore function essentially as an aquatic system. Typically, 75 to 85 percent of the annual precipitation occurs during the months of June through October. Since Southwest Florida wetlands depend upon rainfall as their major source of inflow water, water levels within wetlands systems closely follow seasonal rainfall patterns. Maximum water levels occur near the end of the wet season (October - November) while water levels generally decline during the dry season, reaching lowest levels during April and May. The majority of animals which inhabit Southwest Florida are adapted to this annual cycle. The reproductive success of several key species is closely tied to the rate of water level recession and the concentration of food resources that occurs during the dry season (Ogden *et al.*, 1987; Robertson and Kushlan, 1974).

The presence of surface water within a wetland is essential for maintaining wetland aquatic productivity, i.e., the growth and reproduction of aquatic organisms such as insects, small forage fish, amphibians, crayfish, freshwater shrimp, snails and other invertebrates that form the basis of the food chain for higher trophic level organisms such as amphibians, reptiles, wading birds and raptors which utilize these wetlands (Kahl, 1964; Kushlan, 1976, 1978; Frederick and Collopy, 1988). Overdrainage of wetlands by ground water withdrawals or surface drainage directly impacts this annual cycle by reducing wetland size, as well as the amount, number and kinds of microorganisms produced by wetlands. Therefore, large-scale drainage of wetlands has a great potential to impact the regional food supplies, breeding and nesting areas for many species of wildlife.

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Decrease in Wetland Size

The most obvious impact of reducing water levels is a decrease in size of the wetland. This is especially true of shallow, low gradient wetlands which may be completely eliminated. Decrease in wetland size reduces the available wildlife habitat and the area of vegetation capable of nutrient assimilation. It also reduces the water surface area, and corresponding ET and evaporation rates, which can have an influence on the rain cycle and regional climatic conditions.

Degradation of Fish and Wildlife Habitat

A decrease in wetland size reduces the available wildlife habitat. The accompanying changes in vegetative composition and diversity, and loss of aquatic productivity impacts the breeding and nesting areas for many species of wildlife.

Invasion by Exotic Plants

Invasion by exotic plants such as melaleuca and brazilian pepper is encouraged by changes in the depth and/or duration of wetland water levels. Melaleuca adapts well to alternating flood and drought conditions, and can form thick, monotypic stands that have very little wildlife value. Melaleuca also exhibits a high rate of ET and is very tolerant of fires, sprouting readily from the root stock after burning. The threat from this aggressive and difficult to control species argues strongly against allowing any further decreases in water levels or hydroperiods in the wetlands.

Alteration of Historical Surface Water Flows

Changes in water levels can also affect surface water flow patterns within and between wetlands. Reductions of the amount of surface water flow from wetlands can also have a negative effect on the salinity balance in estuarine habitats. This can be detrimental to the productivity of seagrass beds, oyster bars, and other valuable coastal environments.

Soil Subsidence and Increase in Fire Potential

With the impact on wetland water budgets that occurs from wellfield drawdowns comes an increase in the frequency and severity of wildfires. Fires are part of the natural process that recycles nutrients from accumulated plant material back into the soil. They are prevalent in the dry season, especially during drought years. Normally, the soil remains wet almost to the surface, protecting the roots of wetland vegetation from damage. When the water table is depressed to unnaturally low levels, the muck soils that underlay many of South Florida's wetlands dry out and become flammable. Resulting muck fires kill natural wetland vegetation, which is replaced by less desirable, weedy species. Even in the absence of fire, overly drained muck oxidizes and breaks down, which can lead to vegetation changes and degradation of wetland function.

Saltwater Intrusion

Wetlands in coastal areas may experience vegetative changes in response to salinity changes. For example, cypress, maple, and other freshwater species can be killed by increased salinity resulting from decreased inflows of fresh water. One way to deal with this situation would be to establish minimum flows, which could lead to constraints on water supply development upstream.

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Other Impacts

There are numerous other activities which affect wetlands that are outside the scope of this report, but may contribute to the cumulative impact on wetland systems (Larson, 1976; Carter *et al.*, 1973; University of Florida, Center for Government Responsibility, 1982; Rochow, 1989; CH₂M Hill, 1988):

- Outright filling and conversion to residential, commercial, industrial, or agricultural uses
- Drainage for pasture
- Rock mining
- Peat mining
- Chemical or biological pollution
- Impounding
- Dumping
- Recreational misuse and overuse
- Noise pollution

Impacts of Ground Water Drawdowns on Uplands

Little is currently known about the hydrologic requirements of upland communities. However, it is known that the water table levels beneath an upland play an important role in defining the vegetative structure and composition of an upland community. Impacts to uplands from water table withdrawals are similar to those encountered by wetlands, such as increased frequency of fire caused by reduced moisture conditions stemming from lower than normal water table elevations. Most natural environments in South Florida depend on appropriate fire regimes to maintain their ecological integrity. Those upland communities that are on the highest and lowest water tables may prove to be the most sensitive to water table level change. Monitoring of upland parameters is needed to provide a better understanding of wetlands.

Impacts of Ground Water Drawdowns on Estuarine and Marine Habitats

Although estuarine and marine habitats are not specifically addressed in the water supply model developed for the LWC Water Supply Plan, these sensitive environments need to be considered whenever management scenarios have the potential to affect freshwater releases to tidewater. The degree of salinity as well as volume, distribution, circulation, and temporal patterns of freshwater discharge all contribute to the character of these systems. In many ways, salinity is a master ecological variable that controls important aspects of community structure and food web organization in coastal systems (Myers and Ewel, 1990). Salinity patterns affect productivity, reproduction cycles, population distribution, community composition, predator-prey interactions, and food web structure in the inshore marine habitat. Disruption of the food web resulting from a salinity imbalance would also have a detrimental impact on commercial and recreational fishing industries. Other aspects of water quality, such as turbidity, dissolved oxygen content, nutrient loads, and toxins also affect functions of these areas (Environmental Coalition of Broward County, 1987; U.S. Department of Agriculture, 1989; Myers and Ewel, 1990).

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Impacts on Wading Birds

The interior freshwater marshes of South Florida are important habitats because of their importance as feeding and nesting areas for a number of endangered or threatened species (wood stork, sandhill crane), or species of special concern (little blue heron, snowy egret, Louisiana heron, least bittern, limpkin). The future of these species is ultimately linked with maintaining healthy, viable wetland systems (Ogden, 1978).

Wading bird species commonly feed upon small fish (1 to 6 inches long) in waters typically 6 to 10 inches deep. Although wood storks and white ibis display different feeding techniques, both species are tactile foragers, meaning they feed by touching prey with their bill and swiftly snapping it shut to catch food. This specialized feeding technique requires a greater concentration of fish than needed by other wading birds, which feed primarily by sight. Therefore, wood stork and white ibis foraging success is affected in situations where total numbers of available fish are reduced as a result of wetland drainage or altered hydroperiods, as compared to wading bird species which feed primarily by sight.

Populations of wading birds have experienced large declines in South Florida. Factors which have led to decreased population levels include loss of habitat, alteration of historical water levels and hydroperiod, increased fire frequency, and overhunting. In some cases, species which inhabit wetland areas have been adversely affected by water management actions which were intended to provide for their protection.

Robertson and Kushlan (1974) estimated the total population of wading birds to be as high as 2.5 million in 1870, declining to less than 500,000 in 1910 as a result of plume hunting. Restrictive hunting legislation enabled populations to increase to an estimated 1.2 million by 1935. Since that time, total populations have declined to levels about 10 percent of the levels recorded during the 1930s (Collopy and Federick, 1986). Ogden (1978) states that the rapid decline in wading bird populations over the last three to four decades is the result of repeated nesting failures caused by inadequate food production. This can be attributed to marshland destruction and altered hydroperiods. Lowered water levels cause shortened reproductive periods for fish and aquatic invertebrates, and increase the frequency of destructive fires. Unusually high water levels during the nesting season cause food resources to be dispersed and unavailable during the critical nesting season.

The status of the endangered wood stork is of particular concern because it nests within the LWC Planning Area (Corkscrew Swamp). Historical populations of wood storks have sharply declined in South Florida. This decline is estimated to be about 80 percent between 1960 and 1980 (Ogden *et al.*, 1987). Population levels averaged about 2000 pairs until 1960, although much variation occurred (Robertson and Kushlan, 1974; Ogden *et al.* 1987). Numbers continued to decline during the 1970s and 1980s after construction of water management structures which delivered water to Everglades National Park (Ogden *et al.*, 1987). Ogden *et al.* has argued that the decline of wading bird populations within Everglades National Park was the result of alteration of the timing and distribution of surface water discharged into the Everglades since the 1960s. The authors indicate that the new water delivery schedule regime resulted in delayed and incomplete dry season drawdowns, which delayed wood stork nesting to the point where the nesting period extended into the wet season, and the adults could no longer obtain a sufficient concentrated food supply to support their young. Water management actions which allowed flood

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releases to the Everglades reversed the annual cycle of declining water levels and dispersed prey concentrations. Loss of peripheral wetlands, due to urban and agricultural development, is also thought to be the a major factor for nesting failures of many wading bird species.

Impacts on Rare, Threatened, or Endangered Species

Loss of habitat and habitat fragmentation are the major causes of the decline in a number of listed rare, threatened or endangered (RTE) wildlife species in South Florida. Reduction in population is due largely to conversion of natural habitats to agricultural and urban uses. Some species, such as the Florida panther and black bear, require large expanses of land to successfully survive as a breeding population. Other species are restricted to one particular type of habitat, such as the Florida scrub jay (pine/oak scrub) or red-cockaded woodpecker (mature pine flatwoods). Listed RTE species within the LWC Planning Area depend on both wetland and upland communities for survival. For example, the Florida panther inhabits uplands, but it frequents wetlands. The reverse is true for other species, such as the wood stork.

Agricultural and urban development have gradually fragmented and reduced the quality and size of existing wildlife habitat. Continued fragmentation of upland and wetland ecosystems has the potential to cause problems for the survivorship of many species. Table F-2 presents a list of the rare, threatened, and endangered species and species of special concern that are found within the LWC Planning Area. The following is a summary of selected species listed in the table.

Florida Panther (*Felis concolor coryi*)

A federally listed endangered species, the Florida panther has been given a high priority status to be saved through the Florida Panther Recovery plan (U.S. Fish and Wildlife Service, 1987). The panther requires a large territorial range, which is rapidly disappearing due to the expansion of agricultural and urban developments. This continued "loss and fragmentation of native landscapes in Southwest Florida will reduce the ability of panthers to function normally and will exacerbate problems associated with low numbers" (Maehr, 1990). Maehr also observed that while wetlands are an important habitat to panthers, they appear to prefer native upland forest habitats in Southwest Florida. The survival of the panther is closely correlated to the preservation of large tracts of contiguous and suitable habitats. Additional habitat losses may be incurred by changes in the hydrology of wetlands and uplands due to drawdown effects from wellfield operations.

Red-Cockaded Woodpecker (*Picoides borealis*)

Also a federally listed endangered species, the red-cockaded woodpecker was once common in the region within mature pine forest habitat. However, logging for timber and clearing for agriculture has significantly reduced this habitat, affecting the woodpecker population size and range. This woodpecker is the only woodpecker species to excavate a nesting cavity in a mature living pine tree, and therefore requires a mature stand of pines for successful nesting. In addition, the woodpecker lives in groups, referred to as clans, that may be as large as nine individuals. Their territories vary in size up to 250 acres, with areas of utilization up to 1000 acres. Soils which support mature pine forests are subject to conversion to agriculture and urban development. Hydrological changes from wellfield development may cause the further loss of pine forest habitat by increased fire frequency.

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Florida Scrub Jay (*Aphelocoma coerulescens*)

The Florida scrub jay is a threatened species that lives within a very restricted habitat range, permanently residing in upland scrub communities. These scrub communities exist on historic sand dunes, and are vanishing due to urban developments and conversion to citrus groves. The protection of this habitat is critical for species survival.

Gopher Tortoise (*Gopherus polyphemus*)

A species of special concern, the Gopher tortoise lives in a variety of habitats. The major cause for decline of tortoise populations has been the conversion of native habitat to agriculture and urban development. In the process of clearing the land, the tortoise is often killed by suffocation due to burial within their burrow. Highway mortality also significantly contributes the decline of this species in Lee County (Lee County, 1989). Gopher tortoise burrows are also utilized by over 80 different wildlife species, such as the Eastern Indigo snake (threatened species) and the Gopher frog (species of special concern).

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TABLE F-2. Selected, Threatened, Endangered, and Species of Special Concern within the Lower West Coast Planning Area.

SPECIES	FGFWFC	USFWS
<u>Amphibians and Reptiles</u>		
American alligator <i>Alligator mississippiensis</i>	SSC	T(S/A)
Eastern indigo snake <i>Drymarchon coralais couperi</i>	T	T
Gopher frog <i>Rana aerolata</i>	SSC	UR2
Gopher tortoise <i>Gopherus polyphemus</i>	SSC	UR2
Florida pine snake <i>Pituophis melanoleucus mugitus</i>	SSC	UR2
<u>Birds</u>		
Audubon's crested caracara <i>Polyborus planus audubonii</i>	T	T
Bald eagle <i>Haliaeetus leucocephalus</i>	T	E
Burrowing owl <i>Athene cunicularia</i>	SSC	
Florida sandhill crane <i>Grus canadensis pratensis</i>	T	
Florida scrub jay <i>Aphelocoma coerulescens</i>	T	T
Limpkin <i>Aramus guarauna</i>	SSC	
Little blue heron <i>Egretta caerulea</i>	SSC	
Osprey <i>Pandion haliaetus</i>	SSC (Monroe Co.)	
Red- cockaded woodpecker <i>Picoides borealis</i>	T	E
Roseate spoonbill <i>Ajaia ajaja</i>	SSC	
Snowy egret <i>Egretta thula</i>	SSC	
Southeastern American kestrel <i>Falco sparverius paulus</i>	T	UR2
Tricolored heron <i>Egretta tricolor</i>	SSC	
Wood stork <i>Mycteria americana</i>	E	E

E = Endangered.

T = Threatened.

SSC = Species of Special Concern.

UR2 = Under review for listing, but substantial evidence of biological vulnerability and/or threat is lacking.

T (S/A) = Threatened due to similarity of appearance.

Source: SWFRPC, 1990.

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TABLE F-2. (Continued).

SPECIES	FGFWFC	USFWS
Mammals		
Big Cypress fox squirrel <i>Sciurus niger avicennia</i>	T	UR2
Everglades mink <i>Mustela vison evergladensis</i>	T	UR2
Florida black bear <i>Ursus americana floridanus</i>	T	UR2
Florida mouse <i>Podomys floridanus</i>	SSC	UR2
Florida panther <i>Felis concolor coryi</i>	E	E
Round-tailed muskrat <i>Neofiber alleni</i>		UR2
West Indian manatee <i>Trichechus manatus</i>	E	E

E = Endangered.

T = Threatened.

SSC = Species of Special Concern.

UR2 = Under review for listing, but substantial evidence of biological vulnerability and/or threat is lacking.

T (S/A) = Threatened due to similarity of appearance.

Source: SWFRPC, 1990.